



INSTITUTE FOR DEFENSE ANALYSES

**A Cost-Benefit Analysis Applied to
Example Proposals for Army
Training and Education Research**

John E. Morrison
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PREFACE

This work was performed under the “Army Learning” task for the Deputy Under Secretary of Defense for Science and Technology (DUSD (S&T)). The operational need for the work was identified by the U.S. Army Training and Doctrine Command (TRADOC). Dr. John E. Morrison was the Institute for Defense Analyses (IDA) Task Leader for the effort. Dr. Kathleen A. Quinkert, Chief of the U.S. Army Research Institute for the Behavioral and Social Sciences’ (ARI) TRADOC Scientific Coordination Office, was the Government’s technical monitor.

Mr. Fred Hartman reviewed an earlier draft of the report and provided many useful comments that were incorporated into the final version. The cost-benefit analysis employed in this report owes much of its spirit, though not the details, to a resource-allocation model used to develop a plan of research on simulation-based training systems (Young, Luster, Stock, Mumaw, and Sticha, 1986).

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EXECUTIVE SUMMARY

A. BACKGROUND AND REQUIREMENT

This document presents a methodology for assessing the value of research and development (R&D) opportunities for Army training and education. The methodology uses cost-benefit analysis to determine potential payoffs of learning science R&D. It is applied to ideas derived from the Army Science of Learning Workshop sponsored by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) at the request of the U.S. Army Training and Doctrine Command (TRADOC). The workshop brought together key stakeholders in Army training and education, experts from academia and industry, and representatives of other Services. The workshop's participants identified learning science findings and technologies to help the Army train Soldiers and grow leaders for today and tomorrow.

The workshop's participants were assigned to one of four working groups (Learning Model, Train Soldiers, Develop Leaders, and Future Capabilities) based on their expertise. Each working group was chaired by a facilitator, who was a senior ARI researcher, and assisted by a stakeholder, who represented TRADOC interests. The working group chair nominated participants for their respective groups and developed the objectives for their activities, which are described as follows:

- **Learning Model.** This group examined learning models of other Services and organizations to extract best practices and lessons learned that could be applicable for an Army learning model.
- **Train Soldiers.** This group examined the reshaping of the Army's training and education system. It focused on how advances in the science of learning have provided new pedagogical techniques, procedures, and technologies that can be used to offset pending schoolhouse resource reductions.
- **Develop Leaders.** This group examined what we know about "adaptability" and explored possible strategies for accelerating the growth of key leader skills that are thought to support adaptability. It also discussed some of the organizational factors (socialization, cohesion) that help establish the climate within which adaptable leaders perform.
- **Future Capabilities.** This group's goal was to envision what learning science and emerging technologies will offer in the next decade and to articulate

how the Army might take advantage of these technologies to train Soldiers and grow leaders more effectively.

B. APPROACH

The analysis methodology provides estimates of the costs and benefits of R&D projects for TRADOC proponentcy. The intent is to produce a generic approach for assessing and planning research—not just for application to the current set of proposals, but also for use with proposals modified from the present set or with completely new ones. The approach is organized around three analysis components: proposals, cost estimates, and benefit estimates.

1. Proposals

The elements of the current analysis are 21 proposed R&D efforts compiled by the Institute for Defense Analyses (IDA) based on some of the more important concepts that evolved from the workshop's sessions. Each proposal contains basic concepts and estimates of the required time and personnel resources.

2. Cost Estimates

The proposal writers provided cost estimates, which were decomposed into implementation costs, maintenance costs, and other costs (e.g., computer hardware and software). Total costs were calculated in two ways. First, implementation and other costs were summed to estimate the first-year (Y1) start-up costs. Second, a more long-term estimate was calculated by adding maintenance to Y1 costs, assuming a 5-year time frame to correspond with standard Future Years Defense Plan (FYDP) estimates.

3. Benefit Estimates

The benefit of a proposed R&D effort was conceived as being analogous to expected value (i.e., an estimate of the work's operational impact multiplied by the probability of success). Proposal writers estimated the impact of each proposed effort, with the resulting transformed consensus rating ranging from 10 (least important) to 100 (most important). They also estimated the probability of success principally as a function of the proposal's technical feasibility, although some consideration was given to the practical constraints of executing the research.

C. RESULTS

Benefit-to-cost ratios based on both Y1 and FYDP costs were calculated for each of 21 R&D opportunities derived from the workshop. The proposals were sorted by the ratios, and incremental benefit was plotted as a function of incremental Y1 and incremental FYDP costs. The results showed that the method is sensitive to key aspects of cost-benefit analysis including the following three major categories:

1. **Maximize benefits/minimize cost.** An optimal point that balances benefit and cost.
2. **Fixed cost.** For a fixed budget, the function defines a set of R&D proposals that maximizes total benefit.
3. **Fixed benefit.** For a minimum standard of benefit (e.g., 80%), the function defines a set of R&D proposals that minimize costs.

To illustrate the process, consider a package that contains a single proposal. The optimal selection would be the proposal with the greatest benefit-to-cost ratio. The optimal two-proposal package would then include that same proposal plus the one with the next highest benefit-to-cost ratio. By ordering the proposals in this way, one can calculate the total benefit of the proposal packages as a function of their cumulative costs. More generally, this function reveals packages of proposals that optimize specific benefit and cost levels and that are sensitive to using Y1 vs. FYDP cost definitions. Details with extensive examples are presented in the document.

D. CONCLUSIONS

The principal finding of this work is that application of cost-benefit analyses produced sensible alternative plans for a TRADOC R&D program. The costing components of the methodology are well-understood traditional elements of cost-benefit analyses. The innovative aspect of the method—the benefits components—had a notable role in its apparent success. The innovation was to quantify benefit by parsing it into two subcomponents: impact of the effort and the probability of its success. The multiplicative combination of these subcomponents was interpreted as the “expected impact” of the proposed R&D efforts.

Given credible inputs, this document demonstrates how to integrate R&D proposals with an analysis methodology to determine their value to the Army. With that in mind, TRADOC may wish to alter the cost or benefit values and rerun the analysis on the proposed R&D projects. In addition, users of the methodology may want to modify the

objects of analysis (i.e., the R&D proposals). Please note that performing the necessary judgments and achieving a consensus of opinion are themselves nontrivial exercises.

I. INTRODUCTION

A. BACKGROUND

The U.S. Army Training and Doctrine Command (TRADOC) is redefining its role as “Architect of the Army” to better support and shape the Operational Force. In that role, TRADOC is looking outside traditional organizational relationships to gain a better understanding of the fundamental processes that underlie learning and to identify state-of-the-art technologies that enhance learning.

To help TRADOC understand these issues, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) sponsored the Army Science of Learning Workshop on 1–3 August 2006 in Hampton, Virginia (Quinkert, Morrison, Fletcher, Moses, and Roberts, 2007). The workshop brought together key stakeholders in Army training and education, experts from academia and industry, and representatives of other Services. The overall purpose of this workshop was to identify learning science findings and technologies to help the Army train Soldiers and develop leaders for today and tomorrow.

The workshop’s participants were assigned to one of four working groups (Learning Model, Train Soldiers, Develop Leaders, and Future Capabilities) based on their expertise. Each working group was chaired by a facilitator, who was a senior ARI researcher, and assisted by a stakeholder, who represented TRADOC interests. The working group chair nominated participants for their respective groups and developed the objectives for their activities, which are described as follows:

- **Learning Model.** This group examined learning models of other Services and organizations to extract best practices and lessons learned that could be applicable for an Army learning model.
- **Train Soldiers.** This group examined the reshaping of the Army’s training and education system. It focused on how advances in the science of learning have provided new pedagogical techniques, procedures, and technologies that can be used to offset pending schoolhouse resource reductions.
- **Develop Leaders.** This group examined what we know about “adaptability” and explored possible strategies for accelerating the growth of key leader skills that are thought to support adaptability. It also discussed some of the

organizational factors (socialization, cohesion) that help to establish the climate within which adaptable leaders perform.

- **Future Capabilities.** This group's goal was to envision what learning science and emerging technologies will offer within the next decade and articulate how the Army might take advantage of these technologies to train Soldiers and grow leaders more effectively.

B. ORGANIZATION AND OBJECTIVE OF THIS REPORT

This report presents specific proposals for research and development (R&D) that were derived from the Army workshop. The current analysis was done to estimate the costs and benefits of R&D projects for TRADOC proponentcy. This report also documents the development approach for making programmatic decisions about R&D opportunities. The intent is to provide a generic approach for assessing and planning research—not just for application to the current set of proposals, but also for use with proposals modified from the present set or with completely new ones.

II. APPROACH

The present analysis is based on proposals to exploit learning science opportunities related to TRADOC's mission. The proposals were derived from ideas put forth during the Army Science of Learning Workshop. Each proposal was examined for its benefits and costs.

To maximize the benefits from the proposals without regard to costs, the optimal plan would be to select all proposals. However, such costs would be prohibitively expensive. On the other hand, to minimize costs without regard to benefit, the optimal plan would be to select the least expensive proposal (or set of proposals). However, this approach provides no assurance that the results would be of value to the Army.

The present analytic approach represents a more balanced strategy that casts costs and benefits in a trade space from which several alternative plans can be derived and compared. The intent of this section is to document this approach in sufficient detail to allow it to be replicated with alternate proposals and/or a new set of estimated values.

A. PROPOSALS

The elements of the current analysis are 21 proposed R&D efforts. The proposals were compiled by the Institute for Defense Analyses (IDA) based on some of the more important concepts that evolved during the workshop's sessions. These proposals were not always discussed directly during the workshop; rather, they were implied by ideas that the workshop's participants generated.

Each proposal was given a long title to describe its content and a short title (derived from the longer version) to facilitate referring to these proposals in the analyses. Table II-1 summarizes the proposals by providing the long and short versions of the titles, the working group that generated the proposal, and a statement of purpose.

Appendix A provides a detailed description of the proposals. Each description includes an explanation of the underlying concept of the effort and an estimate of required time and personnel resources. The order of proposals in Table II-1 is the same order used Appendix A, but this order does not reflect priority in cost or benefit.

Table II-1. Summaries of Research Proposals

Long Title	Short Title	Statement of Purpose
<i>Learning Model Working Group</i>		
Selective Implementation of the Guided Experiential Learning (GEL) Model	The GEL Model	Apply a GEL model to a small but diverse set of training objectives
Implementation of a Human Performance Improvement (HPI) Program in the Army	HPI in the Army	Study HPI to determine the appropriate method for implementing it in the Army
Blending Distance Learning With Traditional Instruction	Blended Learning	Review civilian literature on blending virtual and live training to interpret application to constraints of Army training
Models To Predict Effectiveness and Efficiency of Training and Education	Predictive Models	Based on modern learning science, develop models to predict the effectiveness and efficiency of training and education
Effective and Efficient Knowledge Acquisition, Management, and Sharing Approaches and Tools	Knowledge Management	Develop an appropriate architecture for knowledge management and supporting tools for the Army
Life-Long Learning Models With Intelligent Agents for Individualized Guidance	Life-Long Learning	Examine alternative models for using intelligent agents to perform mentoring functions
<i>Train Soldiers Working Group</i>		
Systematic Implementation Plan for Distributed Learning (dL)	Implementation Plan for dL	Use dL technology to accelerate training, reduce costs, reduce personnel requirements, and improve operational effectiveness
Research and Development on Distributed Learning (dL) Topics	R&D on dL	Encourage the establishment of R&D programs to guide the development and selection of effective dL strategies, technologies, and authoring tools
Analyses of Training	Analyses of Training	Perform analyses of training inputs and outputs to accelerate training and reduce training costs and personnel requirements
Implementation of Enhanced Training Capabilities	Training Capabilities	Develop capabilities related to Assignment-Oriented Training (AOT) and for training in units
Guidelines for Tools and Methods To Support Training	Training Support Tools	Reduce the “demand side” of training through increased use of performance and decision aiding technology integrated with training design and objectives
New Programs of Research in Training	New Training R&D	Encourage R&D programs to develop a full systems approach that considers costs and benefits of all alternatives for producing human performance
Existing and Evolving Strategies for Tailoring Training	Tailored Training	Systematically apply proven techniques for tailoring training to needs, prior knowledge, capabilities, and interests of individual Soldiers

Table II-1. Summaries of Research Proposals (Continued)

Long Title	Short Title	Statement of Purpose
<i>Train Soldiers Working Group (Continued)</i>		
Existing and Evolving Strategies for Real-Time Diagnostic Evaluation	Diagnostic Evaluation	Exploit and apply proven capabilities related to real-time, diagnostic assessment performed using both explicit testing and routine human-computer interactions
Rapid Conversion of Lessons Learned	Lessons Learned	Develop and improve capabilities to rapidly collect, understand, and disseminate lessons learned in theater
<i>Develop Leaders Working Group</i>		
Leader Socialization	Leader Socialization	Investigate collaborative technologies for influencing socialization, particularly in combination with the Army Force Generation (ARFORGEN) model
Critical Thinking Skills	Critical Thinking Skills	Produce courses that blend previous experience in teaching critical thinking with specific recommendations to improve the training and use of such skills
Experience-Based Learning Methods	Experience-Based Learning	Develop multimedia technology that encourages leaders to discover and learn about past conflicts from different perspectives and analytical approaches
<i>Future Capabilities Working Group</i>		
Improvisation	Improvisation	Directly teach the art of improvisation to address the need for "adaptive" capabilities
Folksonomies	Folksonomies	Develop tools that would allow individuals and teams of deployed personnel to document and organize their experiences
Team Task Analysis/ Behavior Modeling	Team Task Analysis	Develop tools to analyze task performance from anthropological models

B. COST ESTIMATION

For each proposal, the individual who developed the concept also provided cost estimates. These estimates were decomposed into the following cost elements:

- **Implementation costs.** These are the costs required to develop and implement the intervention, tool, or methods and are estimated by the number of professional staff-months required.
- **Maintenance costs.** These are the costs required to maintain the intervention, tool, or methods. The cost metric was the number of staff-months per year.

- **Other costs.** These are the significant cost elements required to implement a proposal above and beyond personnel costs. Examples include specific computer hardware or software.

Total costs were calculated in two ways. First, the “implementation” and “other” costs were summed to estimate the first-year (Y1) start-up costs. Second, a more long-term estimate was calculated by adding “maintenance” costs to Y1 costs, assuming a 5-year time frame to correspond with standard Future Years Defense Plan (FYDP) estimates.

C. BENEFIT ESTIMATION

For the present purposes, the benefit of a proposed R&D effort was measured by its “expected impact.” This value was conceived as being analogous to expected value and was defined as the product of the work’s operational impact and the probability of success. The two component values of benefits—impact and probability of success—were put into operation as follows.

1. Impact

The method for estimating impact was adopted from the Simple Multiattribute Rating Technique (SMART) developed by Edwards (1977). Initially, each of the proposal writers independently ranked the entire set of proposals from 1 (most impact) to 21 (least impact)—with ties in ranks allowed. After the estimates were recorded, the writers then met face-to-face to resolve differences in the proposals’ rank ordering. Given the rank orders, the raters were tasked to convert the ranks to ratio measures by assigning the least important proposal an arbitrary value of 10.¹ The rater then considered the next least important proposal and determined how much more important (if at all) it was than the least important. This proposal then was assigned a number reflecting that ratio. This process was continued up the list, checking each set of implied ratios as each new judgment was made. Thus, if one proposal was assigned a weight of 20 and another was assigned a weight of 80, it meant that the 20 proposal was one-fourth as important as the 80 proposal, and so forth. The upper ends of the scale were allowed to vary, resulting in scales ranging from 10–40 to 10–200. The final scale was a weighted average of the individual rater scales, which were transformed so that the range of estimated proposal impact varied from 10 (least important) to 100 (most important).

¹ According to Edwards (1977), the starting point 10 “... is used rather than 1 to permit subsequent judgments to be finely graded and nevertheless made in integers” (p. 328).

2. Probability of Success

Along with rating the importance of the proposals, the proposal writers estimated the probability of success, principally as a function of the proposal's technical feasibility, although some consideration was given to the practical constraints of executing the research, such as organizational missions, policies, and traditions that may change only with intervention at the level of the Army Chief of Staff. Like the impact estimates, raters independently estimated these probabilities.

D. COMPILATION/PRESENTATION OF COST-BENEFIT ESTIMATIONS

These initial estimates were compiled and presented to all the proposal writers in a face-to-face meeting. The resulting values are averages that the proposal writers agreed captured the group's consensus.

III. RESULTS

This section presents results from the analyses of the 21 R&D opportunities derived from the Army Science of Learning Workshop. These results refer to the proposals by short titles. Table II-1 lists the corresponding longer titles, and Appendix A contains a description of the proposals.

A. COST ANALYSIS

Table III-1 summarizes the estimated costs related to the 21 proposed efforts. For the staff estimates, note that most efforts allowed for parallel work from multiple staff members so that the chronological time to develop was often much less than the staffing estimates. The Y1 start-up costs (i.e., development and implementation) ranged from \$187.5K to \$9.4M for individual efforts, with a total of \$23.4M for the entire set of 21 proposals. The total estimated costs over a 5-year FYDP planning cycle showed more variability, ranging from \$187.5K to \$46.9M, with a total of \$76.4M for the entire set. These total potential costs varied more than the start-up costs because they included the start-up costs plus the costs of maintaining tools and methods and/or additional related costs.

B. BENEFITS ANALYSIS

Table III-2 presents the two components of the benefits analysis: the multiplicative product of the probability of success, $p(S)$, and its rated impact. The values of $p(S)$ were generally moderate to high, ranging from .45 to .85, which reflected the analysts' determination that most of the proposed efforts were technically feasible (i.e., not highly risky). The impact ratings ranged from 10 to 100 and represented the numerical ratios among proposals. For instance, the highest rated proposal was estimated to have 10 times the impact of the lowest rated proposal. The two ratings were positively—but not significantly—correlated ($r = .35$, $p > .11$), suggesting that the judges were rating the proposals on substantially different dimensions.

Table III-1. Costs Related to Proposals

Short Titles	Personnel Costs (Staff-Months)		Total Costs (K Dollars)	
	Implement- ation	Maintenance (Per Year)	Y1 Costs	FYDP Costs
The GEL Model	12	6	250	750
HPI in the Army	24	0	500	500
Blended Learning	9	0	188	188
Predictive Models	36	0	750	750
Knowledge Management	48	12	1,000	2,000
Life-Long Learning	48	12	1,000	2,000
Implementation Plan for dL	34	2	708	875
R&D on dL	24	24	500	2,500
Analyses of Training	14	8	292	958
Training Capabilities	18	3	375	625
Training Support Tools	48	6	1,000	1,500
New Training R&D	18	18	9,375 ^a	46,875 ^a
Tailored Training	12	3	250	500
Diagnostic Evaluation	36	12	750	1,750
Lessons Learned	24	12	500	1,500
Leader Socialization	26 ^b	0	542	542
Critical Thinking Skills	60	4	1,250	1,583
Experience-Based Learning	24	1	500	583
Improvisation	21 ^c	9 ^d	438	1,188
Folksonomies	36	0	2,250 ^e	8,250 ^e
Team Task Analysis	48	0	1,000	1,000

Note for Table III-1: Personnel costs based on \$20,833 per staff-month (or \$250,000 per staff-year). Also, costs are rounded to the nearest thousand.

^aIn addition to staffing costs, totals include \$9M/year budget for extramural research.

^bIncludes additional personnel costs required to develop a single test course.

^cIncludes additional personnel costs related to curriculum development in first year.

^dIncludes personnel costs related to follow-on assessment.

^eIncludes game development and hardware costs.

Table III-2. Benefits Related to Proposals

Short Titles	$p(S)$	Impact Rating (10–100)	Proportion Total Benefit
The GEL Model	0.75	15	0.0177
HPI in the Army	0.45	10	0.0071
Blended Learning	0.80	15	0.0189
Predictive Models	0.50	45	0.0355
Knowledge Management	0.70	75	0.0828
Life-Long Learning	0.60	55	0.0520
Implementation Plan for dL	0.85	100	0.1340
R&D on dL	0.65	40	0.0410
Analyses of Training	0.65	65	0.0666
Training Capabilities	0.80	35	0.0441
Training Support Tools	0.75	20	0.0236
New Training R&D	0.50	15	0.0118
Tailored Training	0.80	90	0.1135
Diagnostic Evaluation	0.70	85	0.0938
Lessons Learned	0.70	60	0.0662
Leader Socialization	0.65	20	0.0205
Critical Thinking Skills	0.50	55	0.0434
Experience-Based Learning	0.75	40	0.0473
Improvisation	0.55	15	0.0130
Folksonomies	0.65	10	0.0102
Team Task Analysis	0.80	45	0.0568

The benefit value for each proposal was calculated and then summed over the entire set of 21 proposals. The total was used to determine the proportion of total benefit attributed to each proposed effort, as shown in the right-most column in Table III-2. These values for the individual proposed efforts ranged from almost 1% to over 13% of the total benefit of the entire set of proposals.

C. COST-BENEFIT TRADEOFFS

Table III-3 summarizes the values used to determine cost-benefit tradeoffs. For each proposal, the benefit-to-cost ratio (i.e., benefit per unit cost) was calculated twice: for Y1 costs and for FYDP costs. These ratios were then used to rank the proposed efforts from 1 (the most cost beneficial) to 21 (least cost beneficial). The effect of calculating benefit-to-cost ratios based on FYDP vs. Y1 costs was to change the relative rankings of the proposed efforts. Overall, the rankings differed by 4 or more positions for 8 of the 21 proposals. Specifically, relatively large maintenance costs increased total FYDP costs and reduced the benefit-to-cost rankings of four proposals: (1) The GEL Model, (2) R&D on dL, (3) Analyses of Training, and (4) Lessons Learned. Likewise, the lack or relative lack of maintenance costs reduced total FYDP costs and increased the relative standings of four other proposals: (1) Blended Learning, (2) Predictive Models, (3) Experience-Based Learning, and (4) Team Tasks Analysis.

These benefit-to-cost ratios were then used to select optimal subsets or “packages” of proposed efforts. To illustrate this process, consider a package that contains a single proposal. The optimal selection would be the proposal with the greatest benefit-to-cost ratio. The optimal two-proposal package would then include that same proposal plus the one with the next highest benefit-to-cost ratio. By ordering the proposals in this way, one can calculate the total benefit of the proposal packages as a function of their cumulative costs. More generally, this function reveals packages of proposals that optimize specific benefit and cost levels.

1. Tradeoffs Using Y1 (Start-up) Costs

To illustrate this concept, Figure III-1 displays the cumulative Y1 costs and benefits of proposed efforts ordered by benefit-to-cost ratios. The slope starts out very steep but decreases over the range of this curvilinear function. Also, as noted on the graph, the last proposal (New Training R&D) added very little additional benefit, considering its relatively large costs. Consequently, this proposal was an outlier relative to the 20 other proposals and could not be shown in its actual position without distorting the function. (Table B-1 in Appendix B displays the cumulative Y1 costs and benefits for all proposals.) The following discussion shows that the method is sensitive to key aspects of cost-benefit analysis (i.e., maximize benefit/minimize cost, fixed costs, fixed benefits).

Table III-3. Benefit-to-Cost Ratios

Short Titles	Y1 Costs		FYDP Costs	
	Benefit-to-Cost Ratio	Rank	Benefit-to-Cost Ratio	Rank
The GEL Model	0.0450	11	0.0150	15
HPI in the Army	0.0090	19	0.0090	18
Blended Learning	0.0640	7	0.0640	3
Predictive Models	0.0300	14	0.0300	9
Knowledge Management	0.0525	9	0.0263	11
Life-Long Learning	0.0330	13	0.0165	14
Implementation Plan for dL	0.1200	3	0.0971	2
R&D on dL	0.0520	10	0.0104	16
Analyses of Training	0.1449	2	0.0441	6
Training Capabilities	0.0747	6	0.0448	5
Training Support Tools	0.0150	18	0.0100	17
New Training R&D	0.0008	21	0.0002	21
Tailored Training	0.2880	1	0.1440	1
Diagnostic Evaluation	0.0793	5	0.0340	8
Lessons Learned	0.0840	4	0.0280	10
Leader Socialization	0.0240	15	0.0240	12
Critical Thinking Skills	0.0220	16	0.0174	13
Experience-Based Learning	0.0600	8	0.0514	4
Improvisation	0.0189	17	0.0069	19
Folksonomies	0.0029	20	0.0008	20
Team Task Analysis	0.0360	12	0.0360	7

a. Maximize Benefits/Minimize Costs

There is a point in the function where the returns in benefit begin to diminish rapidly for cumulative investments. This point appears to be at about the fifth proposal (see Figure III-1). Consequently, a package comprising those five proposals (Tailored Training, Analyses of Training, Implementation Plan for dL, Lessons Learned, and Diagnostic Evaluation) would provide nearly 47% of the total benefit of the entire set of proposals for less than 11% of the total costs (or \$2.5M in Y1 costs).

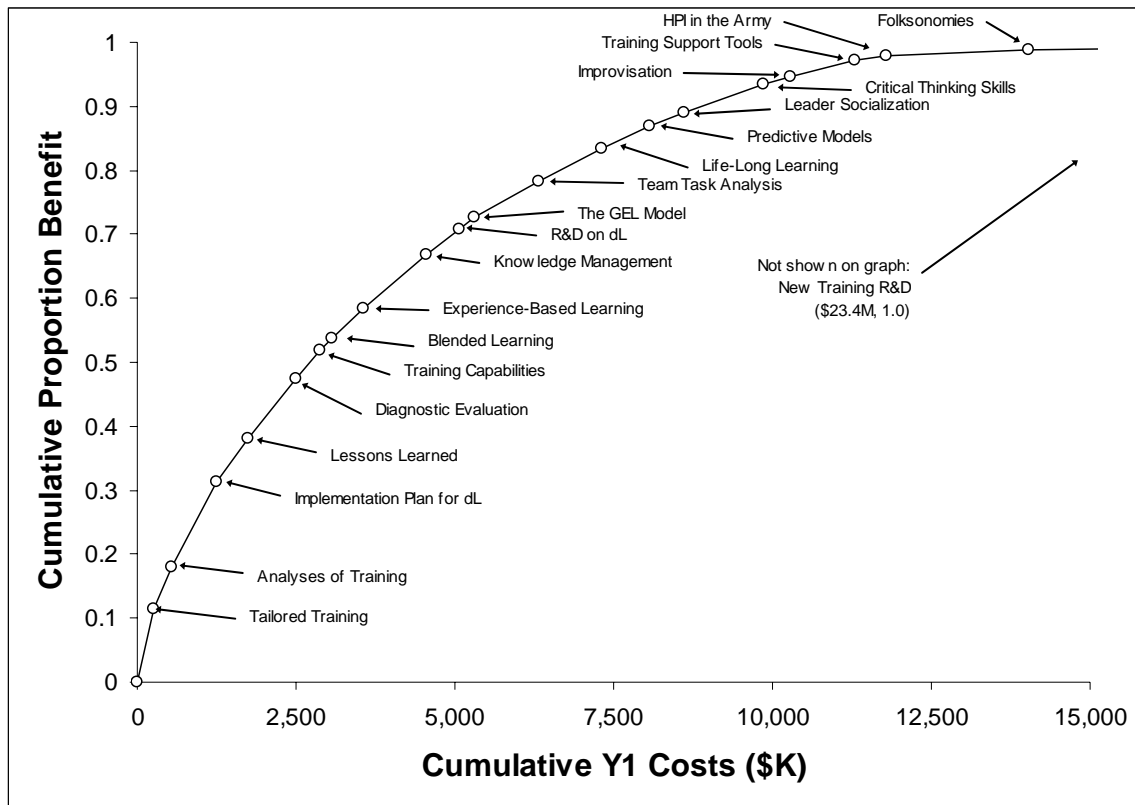


Figure III-1. Incremental Benefit as a Function of Cumulative Y1 Costs

b. Fixed Costs

In this case, the funding organization has a fixed amount of money for investment and wants to ensure that it constructs the optimal package (i.e., the one that maximizes total benefit). The procedure is to choose the proposals in order of cost-benefit ratio until the total cumulative cost is approximately equal to the fixed amount. Using the present data as an example, suppose that a total of \$5M was available in Y1 money. Assuming that the total must not exceed this budget, the optimal package would then comprise the first five proposals in the previous package plus four more: Training Capabilities, Blended Learning, Experience-Based Learning, and Knowledge Management. This nine-proposal package would account for over two-thirds (67%) of the total benefit.

c. Fixed Benefits

In this case, the funding organization wants to ensure that a package of proposals provides some stated level of benefit. The optimal package in this case is the one that minimizes cost for the fixed benefit. For the sake of illustration, suppose the funding organization wanted a package that accounted for at least 80% of the benefit derived

from the total set of 21 proposals. The optimal package (i.e., the one that minimizes Y1 cost) would then comprise the nine proposals specified in the previous package plus four more: R&D on dL, The GEL Model, Team Task Analysis, and Life-Long Learning. This 13-proposal package, which accounts for approximately 83% of the benefit, would cost \$7.3M, which represents about 31% of the total cost of all 21 proposals.

2. Tradeoffs Using FYDP Costs

Figure III-2 presents the same sort of information as Figure III-1, but this information is based on FYDP costs instead of Y1 costs. As discussed previously, this distinction changed the rank order of the proposals (i.e., considering FYDP costs instead of Y1 costs provides different optimal selections). As in Figure III-1, the New Training R&D proposal was the last to be added and is not shown in its actual place on the function. (Table B-2 in Appendix B displays the cumulative FYDP costs and benefits for all proposals.) The examples that follow are meant to parallel those described for Y1 costs.

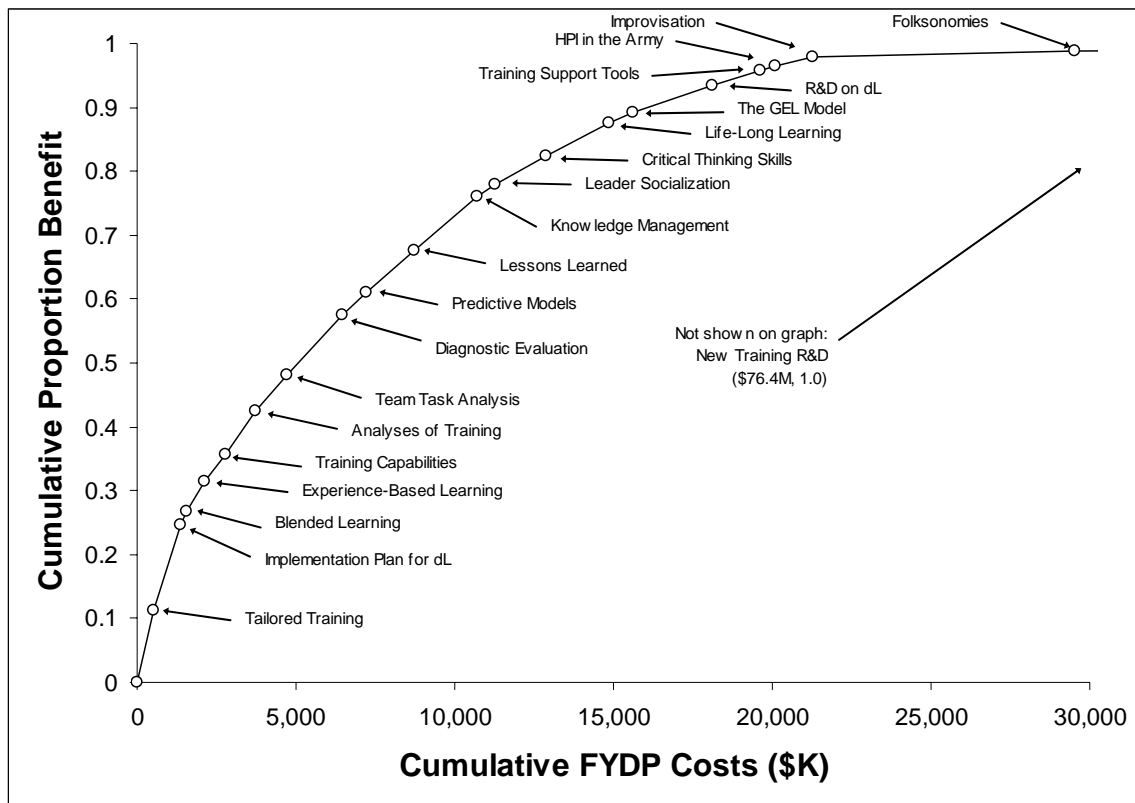


Figure III-2. Incremental Benefit as a Function of Cumulative FYDP Costs

a. Maximize Benefits/Minimize Costs

The point where the returns in benefit begin to diminish rapidly for cumulative investments) is not as obvious in Figure III-2 as it is in Figure III-1. However, to parallel the previous analysis, the first five proposals were chosen: Tailored Training, Implementation Plan for dL, Blended Learning, Experience-Based Learning, and Training Capabilities. This package appears cost-beneficial in that well over one-third of the total benefit (36%) would cost about \$2.8M. However, this cost is a much smaller fraction of the total cost (about 4%) because the FYDP costs have a much larger range than the Y1 costs. Also, although this five-proposal FYDP package roughly parallels the corresponding Y1 package, the contents are substantially different. Of the five proposals in both the Y1 and FYDP analyses, only two (Tailored Training and Implementation Plan for dL) are common to both lists.

b. Fixed Costs

It would seem reasonable that the amount of FYDP money available would be greater than the amount of Y1 money available. Suppose that \$8M was available across the FYDP, which provided the cap for the budget. In this case, the optimal package (i.e., the one that maximizes benefit) would also comprise nine proposals—the five contained in the previous package plus four more: Analyses of Training, Team Tasks Analysis, Diagnostic Evaluation, and Predictive Models. This package would consume \$7.2M of the \$8M budget and would account for the maximum benefit possible (61% of the total).

c. Fixed Benefits

Paralleling the Y1 package, it is assumed that the funder desires a package that accounts for at least 80% of the total benefit. The optimal package (i.e., the one that minimizes cost) would then comprise the nine proposals specified in the previous package plus four more (Lessons Learned, Knowledge Management, Leader Socialization, and Critical Thinking Skills). This 13-proposal package, which accounts for approximately 82% of the benefit, would cost about \$12.9M.

3. Summary of Packages

Table III-4 summarizes these various packages of proposals derived from Y1 and FYDP costs. The proposal numbers (e.g., 1, 2, 3, and so forth) refer to their relative rank in benefit-to-cost ratios, starting with the most cost-beneficial proposal. For packages that

Table III-4. Optimal Proposal Packages Based on Y1 vs. FYDP Cost Estimates

Package Feature	Based on Y1 Costs			Based on FYDP Costs		
	Proposals	Cost	Percent Total Benefit	Proposals	Cost	Percent Total Benefit
Maximize benefits/ minimize cost	1. Tailored Training 2. Analyses of Training 3. Implementation Plan for dL 4. Lessons Learned 5. Diagnostic Evaluation	\$2.5M	47%	1. Tailored Training 2. Implementation Plan for dL 3. Blended Learning 4. Experience-Based Learning 5. Training Capabilities	\$2.8M	36%
Fixed costs	<i>All above (Y1), plus</i> 6. Training Capabilities 7. Blended Learning 8. Experience-Based Learning 9. Knowledge Management	\$4.6M	67%	<i>All above (FYDP), plus</i> 6. Analyses of Training 7. Team Task Analysis 8. Diagnostic Evaluation 9. Predictive Models	\$7.2M	61%
Fixed benefits	<i>All above (Y1), plus</i> 10. R&D on dL 11. The GEL Model 12. Team Task Analysis 13. Life-Long Learning	\$7.3M	83%	<i>All above (FYDP), plus</i> 10. Lessons Learned 11. Knowledge Management 12. Leader Socialization 13. Critical Thinking Skills	\$12.9M	82%

have similar features (rows in the table), the results show differences because of cost definition (Y1 or FYDP). As the packages decrease in cost-benefit (see the bottom row in particular), the two definitions produce greater divergence. Using the Y1 definition, the bottom row includes three proposals that do not appear on any selections using the FYDP definition: R&D on dL, The GEL Model, and Life-Long Learning. These results suggest that these three proposals accrue a short-term cost-benefit that is not reflected in the FYDP cost definition. Likewise, using the FYDP definition, the bottom row contains two proposals that do not appear on any of the selections using the Y1 definition: Leader Socialization and Critical Thinking Skills. These results suggest that these two proposals are viewed as cost effective only if a longer costing window (5 years) is assumed.

The observed differences discussed previously demonstrate that the methods described herein (Y1 and FYDP) are sensitive to the costing method used.² Despite these differences, some commonality existed in proposal selections between the two methods. To provide a single recommendation that balances short- and long-term perspectives, a “compromise” package was assembled. This package comprised the top 10 proposals based on the average rank for the two benefit-to-cost ratios. Table III-5 lists the resulting package in priority order, from most to least cost-benefit. As indicated, the total cost of this package over the FYDP would be less than \$10M. However, over half of that FYDP costs (\$5.6M) would be incurred in Year 1.

Table III-5. Recommended Package of Proposals Based on Both Cost Estimates

Proposals	Y1 Cost (\$K)	FYDP Cost (\$K)
1. Tailored Training	250	500
2. Implementation Plan for dL	708	875
3. Analyses of Training	292	958
4. Blended Learning	188	188
5. Training Capabilities	375	625
6. Experience-Based Learning	500	583
7. Diagnostic Evaluation	750	1,750
8. Lessons Learned	500	1,500
9. Team Task Analysis	1,000	1,000
10. Knowledge Management	1,000	2,000
<i>Totals</i>	<i>5,563</i>	<i>9,979</i>

D. ILLUSTRATION OF SELECTION OUTCOMES

Ultimately, the validity of the method is a function of the benefit-to-cost ratios. The discussion that follows documents how these ratios are determined and how the values determine the selection of specific proposals. The intent is to help the reader understand current results and also to understand the method’s use for future applications. Nine

² There is reason to believe that the method would be similarly sensitive to the method for determining benefit, although no alternative was considered for the present set of proposals.

proposals were chosen either because they consistently ranked high or low in benefit-to-cost ratios or their rank was substantially changed because of the cost definition used (Y1 vs. FYDP).

1. Proposals Consistently Ranked High

Two proposals (Tailored Training and Implementation Plan for dL) were consistently ranked high in benefit-to-cost ratios, regardless of cost definitions. The two proposals were similar because the same three factors accounted for high rank:

1. Both proposals were based on a proven record of research; thus, the probability of success, $p(S)$, was rated high: .80 for Tailored Training and .85 for Implementation Plan for dL.
2. Both proposals were considered highly relevant to current training operations, and were thus rated high for their potential impact. In fact, these two proposals received the two highest impact ratings out of all 21 proposals: 100 for Implementation Plan for dL and 90 for Tailored Training.
3. Both proposals incurred some maintenance costs, but these costs were relatively low (i.e., a fraction of a staff-year). Their total FYDP costs, while not the lowest of the entire set, were relatively low.

2. Proposals Consistently Ranked Low

Three proposals (New Training R&D, Folksonomies, and Implementation of HPI) were similar because they were consistently ranked low in benefit-to-cost ratios. However, the reasons for this result were different for the three proposals. These findings were particularly useful because they revealed conditions under which proposals are not selected.

a. New Training R&D

The New Training R&D proposal was rated low in impact (15 on a scale of 100) and low in probability of success (.5). In the defense of these low ratings, we believe that good research should be technically challenging (i.e., low in probability of success) and not necessarily applicable to operation—at least immediately. However, our assumption was that TRADOC was more interested in applied (as opposed to theoretical) research, and the definitions of impact and probability of success reflect that assumption.

The New Training R&D proposal was also the most costly of the 21 proposals, incurring nearly \$47M over the FYDP. In addition to a small staffing requirement, this total includes the cost of the research itself, estimated to be \$9M per year. Obviously, the

cost would be drastically reduced for the funding organization if research funds were provided by an external organization.

b. Folksonomies

The Folksonomies proposal was based on established anthropological methodology, so the value for $p(S)$ was rated as fairly moderate (.65). Two other factors were more important to its consistent low rating:

1. The overall FYDP costs (\$8.25M) were second only to New Training R&D, largely because these costs included \$7.5M for hardware and for software development. If this proposal were reconsidered, the validity of these cost estimates would be a likely target.
2. Folksonomies (along with Implementation of HPI) shared the lowest impact rating (10) of all proposals. It was based on anthropological methods with which the raters were less than fully conversant. For this proposal to be reconsidered, increased emphasis would have to be placed on methodology and the description of potential impact.

c. Implementation of HPI

Ironically, the proposal writers thought that the potential impact of the HPI concept (if implemented correctly) was one of the largest in the set. The problem is that the large potential impact came at a high cost—in terms of financial investment and disruption to the organization. To limit cost risks, the proposal was scoped back to a simple assessment of alternatives for planning purposes. Although this approach clearly limited the investment (\$500K over the entire FYDP), it also limited the estimated impact of the proposal to one of the lowest values in the set. Furthermore, even though HPI has worked well for the Navy and the Coast Guard, the raters were skeptical that it could be implemented as well in the Army. Thus, the probability of success (.45) was also markedly low for this proposal. An unintentional finding from this proposal is that the method is very sensitive to the scope of the proposed effort.

3. Proposals Affected by Cost Definitions

The rankings of four proposals were especially sensitive to cost definitions, either declining or increasing when total FYDP costs were considered.

a. Proposals Rated Lower Using FYDP vs. Y1 Cost Definitions

Two proposals (R&D on dL and Lessons Learned) substantially declined in ranking when total FYDP costs were considered. For both proposals, this drop was

caused by the same factor: the substantial staffing requirements required to maintain the proposed work over all 5 years of the FYDP.

R&D on dL incurs \$500K (24 staff-months) for the first year but a total of \$2.5M when the 24 staff-months were maintained over the entire FYDP. As a result, this proposal dropped in rank from 10th using Y1 cost definitions to 16th using the FYDP definitions. Similarly, Lessons Learned required 24 staff-months in the first year (i.e., \$500K) but only 12 staff-months for the remaining years in the FYDP (\$1.5M total). As a result, this proposal dropped in rank from 4th using Y1 cost definitions to 10th using the FYDP definitions. Both proposals illustrate how sensitive this technique is to the requirement to maintain efforts over the FYDP.

b. Proposals Rated Higher Using FYDP vs. Y1 Cost Definitions

Two proposals (Predictive Models and Team Task Analysis) improved in ranking when FYDP costs were considered. In terms of benefit-to-cost ratios, Predictive Models improved from 14th to 9th and Team Task Analysis improved from 12th to 7th. In both cases, the reason for this upward shift was the obverse of reason for the downward shift described previously. That is, both Predictive Models and Team Task Analysis were conceived as 1-year projects with no follow-on costs.

IV. CONCLUSIONS

The overall conclusion from this study is that the application of cost-benefit analytic methods resulted in sensible alternative plans for a TRADOC R&D program in Army training and education. The costing components of the methodology are well-understood traditional elements of cost-benefit analyses. The innovative aspect of the method—the benefits’ components—had a notable role in its apparent success. The innovation was to quantify the benefit by parsing it into two subcomponents: impact of the effort and probability of its success. The multiplicative combination of these subcomponents can be interpreted as the “expected impact” of the proposed R&D efforts.

This report describes the method in some detail to promote its application using different data. For instance, TRADOC may wish to alter the cost or benefit values and rerun the analysis on the proposed R&D projects. For the present application, all estimates were provided by the R&D proposal developers. If TRADOC (or other potential users) were to provide its own estimates, specific expertise should be sought to estimate cost (e.g., business or economics) vs. benefit values (e.g., military technology or science). The benefit determination should also be decomposed into the two subcomponents: Military experts who understand the effects of technology on military operations should determine the impact of a proposed R&D effort, and scientists who can judge the technical feasibility of proposals should estimate the probability of success. However, actually performing such judgments and achieving a consensus of opinion are themselves non-trivial exercises.

Potential users may also want to modify the objects of analysis (i.e., the R&D proposals). While no technical impediment exists to such a reanalysis of the work, the authors of this report believe that the current proposals had merit before the analytic method was applied (i.e., they were developed before the analysis—not to demonstrate it). As such, the proposals represent a synthesis of concepts from the Army Science of Learning Workshop, whose participants included experts in training and education and key stakeholders in institutional and unit training in the Army. The strength of this report is the demonstration of how to integrate credible training proposals with an analysis methodology to determine their value to the Army.

REFERENCES

- Edwards, W. (1977). How to use multiattribute utility measurement for social decision-making. *IEEE Transactions on Systems, Man, and Cybernetics*, SMC-7(5), 326–340.
- Quinkert, K. A., Morrison, J. E., Fletcher, J. D., Moses, F. L., and Roberts, E. J. (2007). The Army science of learning workshop (ARI Research Note 2007-2). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Young, P. R., Luster, P. K., Stock, J. A., Mumaw, R. J., and Sticha, P. J. (1986). Optimization of simulation-based training systems: Volume 1 – Plans for model implementation, evaluation, and research (HumRRO Final Report 86-13). Alexandria, VA: Human Resources Research Organization.

GLOSSARY

AOT	Assignment-Oriented Training
ARFORGEN	Army Force Generation
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
CTS	Critical Thinking Skills
dL	Distributed Learning
DUSD (S&T)	Deputy Under Secretary of Defense for Science and Technology
FYDP	Future Years Defense Plan
GEL	Guided Experiential Learning
HPI	Human Performance Improvement
IDA	Institute for Defense Analyses
R&D	research and development
SMART	Simple Multiattribute Rating Technique
TRADOC	U.S. Army Training and Doctrine Command
Y1	Year 1; first year

APPENDIX A.
DESCRIPTIONS OF
RESEARCH AND DEVELOPMENT (R&D) OPPORTUNITIES

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I. LEARNING MODEL

Working Group I of the Army Science of Learning Workshop examined learning models of large-scale organizations outside of the Army—including other military Services (Navy and Coast Guard), universities, and corporations—to extract best practices and lessons learned that could be applicable for an Army learning model. This model is descriptive because it explains basic learning phenomena and prescriptive because it provides guidance for instructional development and implementation.

A. SELECTIVE IMPLEMENTATION OF THE GUIDED EXPERIENTIAL LEARNING (GEL) MODEL

1. Concept and Rationale

The GEL model is a structured (i.e., nonconstructivist) approach to instruction. It has much in common with other structured learning approaches, such as the Instructional Systems Design (ISD) model and the Army's System Approach to Training (SAT). The principal innovation of GEL is its integration of modern cognitive learning theory into instructional design and development, particularly the incorporation of cognitive analysis techniques into the design of instruction. Cognitive task analysis provides a set of methods for determining the knowledge structures and processes that underlie competent performance. By providing prescriptions for imparting those structures and processes, cognitive task analysis represents a method for developing and maintaining high levels of performance.

Some differences of opinion exist regarding the appropriateness of GEL to varied types of training content. Some believe that it applies to all types of training objectives, whereas others think that it is applicable only to those objectives that have substantial cognitive requirements. The purpose of the proposed project would be to apply the GEL to a small but diverse set of training objectives. Results would focus not only on metrics related to the design and development of instruction, but also on learning outcomes that result from the implementation of the instruction.

2. Estimated Costs and Benefits

The principal benefit in implementing the GEL model is improved efficiency and effectiveness of training processes and outcomes—improvement estimates on the order of 10% to 20%.

The implementation of GEL could be compressed so that 2 people accomplish this task in 6 staff-months (12 staff-months in all). The primary cost driver is the requirement to keep the GEL program current with research and development (R&D) trends and to educate U.S. Army Training and Doctrine Command (TRADOC) training developers in its application. For these purposes, at least 1 person would be required to devote half his/her time to this effort after the first year (i.e., 6 staff-months per year for the remaining 4 years of the FYDP).

Implementation of GEL could result in avoiding unnecessary costs because of inappropriate use of training design and development methods; however, this benefit is difficult to quantify.

B. IMPLEMENTATION OF A HUMAN PERFORMANCE IMPROVEMENT (HPI) PROGRAM IN THE ARMY

1. Concept and Rationale

HPI is a concept for diagnosing and solving problems in human performance. It assumes that human performance problems can be caused by a lack of skills and knowledge but that these problems can also be caused by deficiencies in job rewards, feedback, equipment, tools, and so forth. Thus, training is but one of many possible interventions (and an expensive one at that) for improving human performance. HPI prescribes a careful analysis of the problem to determine the appropriate intervention.

Although the concept of HPI is perfectly reasonable, its implementation in the Army is problematic. It considers a range of human performance problem interventions that potentially cut across Army organizations. Training, education, or doctrinal interventions are clearly under the purview of TRADOC, but interventions that involve equipment modifications, personnel assignment, and other systems would necessarily involve non-TRADOC organizations. Thus, HPI raises fundamental questions for the Army, including the following: Who should perform the initial analysis? What authorities should he/she possess? Who should oversee the implementation of the intervention? Such questions should be systematically studied to determine the appropriate method for implementing HPI in the Army.

2. Estimated Costs and Benefits

Evidence from other Military Services and from private industry indicates that HPI implementation can have a tremendous return on investment (ROI) in terms of (1) improvements in performance and (2) avoidance of costs related to inappropriate performance interventions. However, to realize such returns, the Army would have to institutionalize the HPI process, which could include significant costs. The proposed study would identify and compare alternative approaches to implementing the HPI process in the Army.

Because the cost and the ROI for HPI implementation are so great, the present proposal is limited—it constitutes only a “plan for a plan.” This preliminary analysis will identify several courses of action. Assuming appropriate data can be obtained, a formal analysis of alternatives (AoA) will then be performed to determine a plan of action that mitigates risk and maximizes ROI.

The estimated costs are based on a compressed schedule of development that involves four professional analysts who have expertise in training, policy, and program assessment. An assumption is that an initial operating capability (IOC) can be reached in 6 months. IOC would be defined as a workable plan for implementing HPI—not implementation of HPI itself.

C. BLENDING DISTANCE LEARNING WITH TRADITIONAL INSTRUCTION

1. Concept and Rationale

Distance learning (dL) is generally recognized as a cost-effective alternative to traditional live methods of delivering instruction. However, some training programs [e.g., the Officer Advanced Course (OAC)] require students to interact with instructors and peers. The Army is now considering how best to blend dL with traditional instruction. Specifically, the Army asks the following questions: How can dL be combined with live instruction to retain the social benefits while reducing training costs? To what extent can virtual interaction be substituted for live interaction?

In the short term, such questions can be answered by reviewing relevant literature on civilian dL—literature that must be interpreted within the constraints of Army training. Nevertheless, this is the quickest way to obtain valid advice on how dL/live courses can be blended. This literature review may also reveal topics that require gathering new data, and this would represent a significant effort. However, the present

proposal is only for the initial literature review because the scope of any data gathering effort cannot be specified before examining the literature.

2. Estimated Costs and Benefits

If such mixed programs were implemented, the potential savings in travel costs and personnel disruption would be considerable. This proposal is limited, however, because implementation is not included as part of the effort. On the other hand, the proposed work will help to identify ways to maximize the benefits of blended learning while minimizing the costs. A compressed time schedule for reaching IOC in 3 months could be met by assigning 3 staff members to the task. IOC is the delivery of the literature review and appropriate recommendations.

D. MODELS TO PREDICT EFFECTIVENESS AND EFFICIENCY OF TRAINING AND EDUCATION

1. Concept and Rationale

The Army should continue exploring new learning models, strategies, and tools to support the evolution of its training system. In particular, the Army should develop models to predict the effectiveness and efficiency of training and education. Such models should incorporate the latest in learning science research and theories. Bjork's (2007, 1994) reviews of cognition and memory effects show how theories and research inform training practices. His analyses of the research are especially important because they lead to concepts that are not intuitively obvious. For instance, he shows that manipulations that speed the rate of learning may not support long-term retention and transfer. On the other hand, certain manipulations that may retard learning ("desirable difficulties") may enhance and prolong performance and promote creative transfer of training to unique situations. Such desirable difficulties include spacing rather than massing study sessions, interleaving rather than blocking practice on separate topics, varying how to-be-learned material is presented, reducing feedback, and using tests as learning events. Some manipulations (e.g., reducing feedback) may enhance retention performance at virtually no costs, while others (e.g., varying instructional conditions) may enhance retention at the cost of prolonging original learning. Thus, the proposed models must account for potential tradeoffs between learning acquisition and retention performance.

2. Estimated Costs and Benefits

The proposed models can be used to predict the effects of such manipulations on learning, retention, and transfer to devise optimal strategies for timing, sequencing, and scheduling the training and testing events. To the extent possible, the model should be derived from existing research findings, although original empirical research may be proposed to fill key gaps. The work will require 3 staff members for 1 year (36 staff-months). Once the model has been developed and submitted to TRADOC, it should not incur additional maintenance costs.

E. EFFECTIVE AND EFFICIENT KNOWLEDGE ACQUISITION, MANAGEMENT, AND SHARING APPROACHES AND TOOLS

1. Concept and Rationale

The pervasiveness of dL technologies and tools has promoted a new approach to acquiring, managing, and sharing knowledge. This knowledge management (KM) approach is embodied in the Army's Battle Command Knowledge System (BCKS). Wikipedia (itself a symbol for the KM approach) defines BCKS "...as the change agent for implementing knowledge management (KM) capabilities into the training and military operations of the United States Army" (Battle Command Knowledge System 2007, August). A recent IDA report (Brooks et al., 2005) analyzed BCKS capabilities and concluded that it is a potentially effective tool for enhancing learning and developing situational understanding. On the other hand, Brooks et al. maintained that BCKS systems architecture is not well integrated and that BCKS's knowledge acquisition processes is not well related to traditional forms of instruction and training. Research is needed to develop an appropriate KM architecture and tools for the Army. This architecture should acknowledge existing technologies (e.g., BCKS) and how these technologies can and should be integrated to promote the effective sharing of actionable knowledge. With implementation of the architecture, the Army may realize the full benefits of KM systems such as BCKS.

2. Estimated Costs and Benefits

The benefit of this effort will occur through improvements in BCKS and other KM capabilities. The architecture work would be substantial, requiring 48 staff-months to develop and 12 staff-months per year thereafter to maintain. One of the not-so-obvious maintenance costs would include the management of the culture change caused by integrating KM into TRADOC practices.

F. LIFE-LONG LEARNING MODELS WITH INTELLIGENT AGENTS FOR INDIVIDUALIZED GUIDANCE

1. Concept and Rationale

Life-long learning views dL and related technologies as the means through which education and training can be provided in numerous contexts and throughout Soldiers' careers. The contexts go beyond traditional institutional and unit training situations and include learning opportunities at home, at the civilian workplace, and even during leisure activities and games. To provide guidance in choosing appropriate opportunities and to assess learning progress, life-long models include personnel (e.g., parents, teachers, work supervisors) who perform an explicit mentoring function. These mentors provide advice on all aspects of learning, but their primary training function is to prescribe experiences appropriate to the individual's stage of learning.

Clearly, one-on-one human mentoring is too expensive to be practical on a large scale. On the other hand, a long history of research on technology-based instruction has demonstrated that many mentoring functions can be accomplished through effective individualization of training. For instance, Learning Management Systems (LMS) have been developed to track an individual's progress and prescribe training exercises appropriate to this progress. The challenge is to expand computer-based mentoring functions beyond particular training courses or syllabi and encompass the whole spectrum of Army training and education. The technology of intelligent agents provides the potential to draw information from disparate sources and make integrated learning prescriptions for individual soldiers. The present proposal is to examine alternative models for using intelligent agents to perform such mentoring functions.

2. Estimated Costs and Benefits

A system of intelligent agents for mentoring functions is viewed as an enhancement of existing technology-based individualized instruction. The first step is to develop an intelligent agent model, or perhaps alternative models, that would be compatible with current distance and individualized training standards. The development work would be substantial, requiring 48 staff-months to execute, but this work would be completed within 1 year. Follow-up costs would be contingent upon recommendations from the initial research, but these costs are estimated to be 12 staff-months per year for the remaining 4 years in the FYDP.

II. TRAIN SOLDIERS

TRADOC continues to be extraordinarily successful in preparing Soldiers for operational duty. The following recommendations are not aimed at “fixing” anything TRADOC does. Rather, they are intended as suggestions to help TRADOC (1) capitalize on recent developments and analyses emerging from the science and technologies of learning and (2) provide additional training more efficiently and with fewer resources. In addition to these recommendations, a few research issues were included as opportunities for consideration.

A. SYSTEMATIC IMPLEMENTATION PLAN FOR DISTRIBUTED LEARNING (dL)

1. Concept and Rationale

The concept of this proposed task is to use dL technology to accelerate training, reduce costs, reduce personnel requirements, and improve operational effectiveness without adversely affecting Soldiers or their families. This goal will be realized through a series of recommended actions.

a. Budget for Up-Front Costs

Although TRADOC can expect significant cost savings/avoidances by using dL, initial investments to develop materials and implement dL capabilities are substantial. Savings through dL can return these initial costs quickly—as early as 2 years in some analyses. However, this will require resources not currently budgeted to develop and implement dL.

Obtaining up-front funding for dL is a major challenge for TRADOC leadership. TRADOC management should develop analyses that show the expected return on the initial investment.

b. Raise Standards and Expectations for Quality

Most of the dL benefits derive from interactivity and the ability to tailor instruction to the learner’s needs. Analyses have shown that these capabilities, in addition to reducing per-hour training costs, allow learners to achieve training objectives more

quickly (about two-thirds of the traditional learning time), thereby freeing learners earlier for assignment to duty stations. Analyses have also shown that an early finish reduces training costs to a greater extent than providing learning at a distance, which also results in considerable cost savings/avoidances. However, using dL simply as method by which learners can progress through material by simply hitting the “return” key obviates most dL benefits. Such training approaches are becoming increasingly common and should be discouraged.

The state of knowledge shows how to achieve the significant benefits promised by dL. The state of practice should rise to meet it. TRADOC leadership should insist on adequate standards and raise expectations for dL quality above the current norm.

c. Establish a Comprehensive Cost Model With Well-Defined Cost Elements for dL Training

Cost analyses are much like research—other analysts can always find errors of omission and commission. Also, if TRADOC decides to undertake an initiative to develop and use dL, TRADOC management should establish a standard dL cost model, sufficiently harmonized with other TRADOC cost models, that would allow explicit cost comparisons to be made for different training approaches.

d. Establish Routine and Continuous Processes and Procedures To Ensure the Quality of dL

TRADOC has processes and procedures for assessing and updating non-dL training, and TRADOC management should ensure that these processes and procedures are extended to dL and sustained by individuals with dL expertise. Periodic formative evaluations of cost and effectiveness should be integrated into all dL programs. For TRADOC management (and perhaps all the Army), establishing these processes and procedures will help ensure quality control when contracting for dL development.

e. Identify and Manage the Cultural, Administrative, and Budgetary Effects of dL

Most TRADOC management, administrative, and budgetary procedures are based on instructor-led classroom learning, with quotas and specifically scheduled beginning and ending times. These procedures create what might be described as a TRADOC—if not Army—training culture. The anytime, anywhere capabilities and processes of dL are anomalies for this culture.

TRADOC leadership will be required to incorporate dL into its training culture. TRADOC management should undertake to identify the specific effects of dL on existing training practices, procedures, and policies and on the ability of TRADOC to incorporate dL as a standard, fully accepted training approach. In this effort, TRADOC management should

- Establish incentives and rewards for early adopters
- Select materials for conversion to dL or development of dL at the learning-module level rather than the course level
- Prepare for and manage second- and third-order dL effects
- Establish processes, procedures, and incentives for supervisors to use in dL training
- Ensure sufficient coordination between training and personnel functions so that Soldiers who begin and end programs of instruction at different times receive assignments quickly to appropriate duty stations
- Establish training programs for learners, instructors (“train the trainer”), and training developers.

2. Estimated Costs

Taken as a whole, the recommended actions would require about 34 staff-months to develop through the first year and then 2 staff-months a year to maintain thereafter. The individual recommendations break down as follows:

- Creating a budget for dL up-front costs will be relatively minor. The major costs will be to obtain the funding required by the budget. Costs to create the budget and obtain funding are estimated to all be about 6 staff-months.
- Costs to devise dL quality standards will be relatively minor. The major costs will arise from the effort and vigilance needed to have quality standards established and maintained. Costs will be about 2 staff-months for the first year and 1 staff-month a year thereafter.
- Most of the cost modeling effort will involve reaching consensus about the cost elements among the many stakeholders, including include how these elements should be defined. Costs to reach the necessary consensus will be at least 14 staff-months for the first year but about 1 staff-month per year thereafter to maintain and modify the model.
- The quality control of courseware should require about 1 staff-month for each dL course. For costing purposes, we assume that the technique is tested on 5 courses that have been carefully selected to represent a variety of content, audiences, and training technology. Total costs would be 6 staff-months.

- Identifying and managing effects of dL should be a one-time cost of 6 staff-months.

B. RESEARCH AND DEVELOPMENT ON DISTRIBUTED LEARNING (dL) TOPICS

1. Concept and Rationale

TRADOC leadership and management should encourage the establishment of R&D programs to

- Guide the development and selection of effective dL strategies for tailoring training content, sequence, and pace to the needs, objectives, and prior knowledge of individual learners
- Determine ways to balance and blend remotely provided dL and face-to-face instruction
- Develop and deliver dL on rugged, handheld devices
- Develop and provide practicable dL “authoring” (for instructional content) and “composing” (for simulation and scenario generation) tools for use by local commanders
- Reduce the cost of dL development “authoring” and “composing” through various means, including the development and use of
 - Sharable instructional objects
 - Capabilities that imbue dL with sufficient “intelligence” to manage and generate training interactions on demand and in real time.

2. Estimated Costs

Setting up an R&D effort for dL capability should require 24 staff-months for Y1 and 24 staff-months per year for the remaining 4 years in the FYDP.

C. ANALYSES OF TRAINING

1. Concept and Rationale

The intent of this proposal is to perform analyses of training inputs and outputs to accelerate training and reduce training costs and personnel requirements. The types of analyses are described below.

a. Establish Roles and Responsibilities and Guidelines To Balance TRADOC's Institutional Responsibility With the Training Needs of Operational Forces

TRADOC management should undertake an initiative in coordination with the operational forces to develop roles and responsibilities and establish them as generally applicable guidelines. A process to review these guidelines periodically and update them as needed should be established and enforced. At a more specific level, TRADOC management should determine the extent to which 40/11 warrior tasks and drills must be trained in Initial Entry Training (IET), assuming the availability of the Army Force Generation (ARFORGEN) program.

b. Establish a Program To Develop, Identify, and Measure Mission-Essential Competencies for Army Operations

The current program of developing, identifying, and measuring essential tasks is a necessary and major contribution to Army training and effective operation. However, it is reductionist. Ways are needed to reassemble tasks—essential and otherwise—into operational capabilities. The Air Force has dealt with this issue by establishing Mission Essential Capabilities (MECs). The Army might benefit from a similar approach suitable for its operational requirements.

TRADOC management should investigate the feasibility and value of establishing MECs for Army personnel and collectives. If such an approach proves feasible and valuable, TRADOC management should develop and implement it.

c. Establish a Program To Assess the Military Value of Training

How much is a pound of training worth? Training is assumed to improve the Army's operational capabilities; however, the extent to which it does so is seldom quantified. Because training must compete for resources with other capabilities whose contributions are more readily quantifiable, it may be literally and frequently shortchanged. TRADOC management should undertake analyses to determine, quantitatively, the military value of training (i.e., to determine the degree to which different sorts of training and training content contribute to operational effectiveness).

2. Estimated Costs

The overall cost for a training analysis program would be about 14 staff-months to establish the program and 8 staff-months per year thereafter to sustain the program. Costs for the individual R&D projects would be as follows:

- The process for establishing individual roles and responsibilities should cost about 12 staff-months to set up and 6 staff-months per year thereafter to sustain.
- The program to develop MECs should cost about 1 staff-month per year thereafter to establish and maintain.
- Costs for assessing the military value of training are especially difficult to estimate. Our best estimate is that it should cost about 2 staff-months to establish the program and 1 staff-month for each of 2 years thereafter.

D. IMPLEMENTATION OF ENHANCED TRAINING CAPABILITIES

1. Concept and Rationale

The goal of this proposal is to develop capabilities to accelerate training and reduce training costs and personnel requirements. Two specific capabilities are described below.

a. Provide Assignment-Oriented Training (AOT) or Tailor Existing Training to an Individual's Current or Pending Duty Assignment

TRADOC leadership should increase the integration of personnel and training functions to establish an effective AOT program. TRADOC management should then coordinate personnel and training databases so that an individual's training can be linked to his/her current or pending duty assignments. To reduce course completion times and costs, this tailoring should, to some appreciable degree, be based on assignment, equipment, and/or theater requirements.

b. Establish Guidelines To Provide Resident Institutional Training in Units

Various means (e.g., mobile training teams, correspondence instruction, video-tele-training, Web-based instruction, dL) are becoming available for resident institutional training in units. TRADOC management should establish and apply guidelines for determining, on a case-by-case basis, the most cost-effective approach for providing training that meets specific individual and unit needs.

2. Estimated Costs

This proposal should require about 18 staff-months to establish and 3 staff-months per year thereafter to maintain. The individual efforts break down as follows:

- To establish a working relationship between personnel and training functions should require about 12 staff-months for the necessary procedures and 2 staff-months per year thereafter to maintain them.
- To provide resident institutional training in units should require about 6 staff-months to establish the guidelines and 1 staff-month per year thereafter to maintain and upgrade the guidelines.

E. GUIDELINES FOR TOOLS AND METHODS TO SUPPORT TRAINING

1. Concept and Rationale

The concept of supporting tools and methods is to reduce the “demand side” of training through increased use of technology integrated with training design and objectives. The technologies suggested are discussed below.

a. Performance and Decision Aids

Training requirements can be reduced to some extent by providing performance and decision aids, such as voice-interactive maintenance aids, embedded operating instructions, electronic manuals, and hand-held advisors. TRADOC management should develop guidelines to identify and apply

- The most cost-effective tradeoffs between training objectives and the provision of duty-site performance and decision aids
- Adjustments that should be made in training objectives and programs, assuming the availability of performance/decision aids
- The proper mix of on-site personnel who will rely on these aids and those who will not.

b. Tools for Soldier Self-Assessment and Self-Directed Learning

Given the many capabilities for distributing training (including but not limited to dL), a Soldier could and should be expected to take more responsibility for his/her professional growth and development. However, he/she needs tools to do this. TRADOC management should provide these tools, which could be made available in various formats (e.g., paper, Web, dL capabilities) to all Soldiers. These tools should permit Soldiers sufficient access to personal and training resource files to allow them to assess their needs for continuing career and professional growth and to match these needs to the training opportunities available to them from TRADOC or any other provider.

c. Continuing Education Units (CEUs)

Related to the previous proposal, TRADOC leadership should encourage professional growth by requiring all Soldiers to complete a program similar to the CEU programs offered by business organizations and academic institutions. TRADOC management should establish

- CEU equivalencies for TRADOC training
- Sufficient coordination between training and personnel functions to ensure that Soldiers receive credit for and assignments commensurate with their training achievements.

2. Estimated Costs

The various tools and methods for supporting training require about 48 staff-months to develop and 6 staff-months per year thereafter to maintain. The costs of the individual methods break down as follows:

- Costs should be about 12 staff-months to establish the guidelines related to performance and decision aids and about 1 staff-month per year to maintain them.
- Costs should be about 18 staff-months to establish tools for Soldier self-assessment and self-directed learning in the first year and 1 staff-month per year thereafter to maintain them.
- The capability to provide and administer CEUs should be about 18 staff-months to develop in the first year and about 4 staff-months per year thereafter to maintain them.

F. NEW PROGRAMS OF RESEARCH IN TRAINING

1. Concept and Rationale

The concept of this proposal is that TRADOC leadership and management should encourage the establishment of R&D programs to address a variety of topics. Although the exact topics for research should not be preordained, the following examples show the types of topics that could be addressed.

a. Developing a Full “System-of-Systems” Approach

Develop a systems-of-systems approach for allocating resources to training. This capability should identify optimal allocations of resources among such functions as

- Selection and training
- Personnel job classification and training
- Ergonomic design and training
- Job design and training.

b. Preparing for the Unexpected

Prepare Soldiers to recognize and successfully handle unexpected situations. This work should address issues of increasing Soldier adaptability but should also attend to capabilities (e.g., creativity, innovativeness, and the general capability to “think outside the box”) needed for successful adaptations.

c. Documenting Cases

Permit commanders to record “cases” (stories of actual military operations) rapidly and easily into a computerized case database, so that

- Principles and lessons learned can automatically be extracted
- Trainers can rapidly incorporate cases and principles into programs of instruction
- Other commanders can use these cases when planning operations.

d. Develop Cognitive Analyses

More fully develop the processes of cognitive task analysis and cognitive readiness assessment for individuals and teams so that these processes reliably produce the same results in all hands.

e. Improve Performance Measurement

Identify and develop reliable (stable), valid (relevant), and precise (discriminating) measures of individual and team proficiencies and capabilities from performance in simulations.

2. Estimated Costs

TRADOC should establish a small (1–2 person) office to manage these and later training research projects of immediate interest and value (about 18 staff-months per year). The office should manage an annual budget supporting about \$9M of R&D efforts per year.

G. EXISTING AND EVOLVING STRATEGIES FOR TAILORING TRAINING

1. Concept and Rationale

The notions of tailored training strategies, real-time diagnostic evaluation, and on-demand learning are intimately tied to dL. Training can be tailored without the use of technology (e.g., Keller, 1968) but only through the use of technology does it become economically feasible. Before the advent of affordable computer technology, tailored training and individualized instruction were viewed as instructional imperatives but economic impossibilities (Scriven, 1975; Keller, 1985). With computer technology, tailored training and individualized instruction are now affordable (Fletcher, 1992; 1997; 2006). dL is an effort to capitalize on this affordability.

Even without tailored training, some benefits of dL remain (e.g., the ability to deliver training and performance aiding anytime, anywhere). However, data show that the benefits of dL are minor compared to the training time and resource savings to be gained from training tailored to the needs, abilities, duty assignments and, especially, prior knowledge of learners (Foster and Fletcher, 2003; Dodds and Fletcher, 2004; Wisher and Fletcher, 2004; Fletcher, 2006). Savings and cost avoidances from dL with tailored training can reduce training time alone by 30% to 50%. Such training would allow TRADOC to continue to fulfill its mission despite downward budget pressures. Beyond savings and costs, of course, the real payoff of tailored training is enhanced operational readiness and effectiveness through ensured human performance whenever and wherever it is needed.

Development of the techniques to use computer technology to tailor instruction began in the 1950s. By the early 1970s, the state of the art provided reliable techniques to

- Adjust a learner's rate of progress, allowing as much or as little time needed to reach specified objectives
- Tailor the content and the sequence of instructional content to each learner's or group of learners' needs
- Adjust the level of instruction, making it as easy or difficult, specific or abstract, applied or theoretical, as necessary
- Adjust to learners' most efficient learning styles (collaborative or individual, verbal or visual, and so forth).

These capabilities have been described, discussed, and reviewed by Galanter (1959), Atkinson and Wilson (1969), Suppes and Morningstar (1972), Fletcher and Rockway (1986), and many others. Unfortunately, the state of practice in this area has

lagged far behind the state of the art. TRADOC should begin an effort to apply these proven techniques systematically.

2. Estimated Costs

Although more research is needed and will prove to be of value, the techniques to tailor training now exist. The expense is in applying them, and the scope of application will determine the cost. However, R&D cited in the literature suggests that cost savings and avoidances realized by using these strategies will significantly exceed the costs of implementation.

The approach suggested is to apply all these methods to a single program of instruction (POI) that experienced trainers deem appropriate for tailored training. Initial start-up costs, which involve developing and implementing the POI, are estimated to be low (12 staff-months) because the methods are known. Follow-on work (3 staff-months per year thereafter) to maintain the program and to assess its effectiveness is required.

H. EXISTING AND EVOLVING STRATEGIES FOR REAL-TIME DIAGNOSTIC EVALUATION

1. Concept and Rationale

Evaluations of learners and learner progress are commonly and intermittently performed using explicit tests, instructor assessments or, even, after action reviews (AARs). These evaluations are worthwhile, if not essential. However, management of any process, including learning processes, benefits from currency and the ready availability of progress assessment. The use of technology in training makes continuous, unobtrusive assessment of learner progress possible, and the use of tailored training techniques, especially those referenced previously, require such assessment (Fletcher, 2002). Just as with the one-on-one instruction provided by human tutors, technology used for diagnostic evaluation is based on models of the learner. The models can be qualitative or quantitative, explicit or implicit, pre-existing or constructed on the fly, but they must be available in some form to enable technology-based evaluations (Bruner, 2004; Fletcher, 1975; Foster and Fletcher, 2003).

As with strategies for tailoring instruction, the state of practice in this area has lagged far behind the state of the art. Capabilities being discovered and rediscovered in areas now covered by Intelligent Tutoring Systems (ITSs) seem particularly promising. TRADOC should begin a systematic effort to apply proven techniques for real-time,

diagnostic assessment. In addition, more and better ways to use the timing, display, and computational capabilities of computers for more precise diagnostic models of learners seem ripe for development. TRADOC should encourage R&D to exploit and apply such capabilities fully through explicit testing or human-computer interactions.

2. Estimated Costs

Although more research about diagnostic evaluation is needed and will prove to be of value, these techniques now exist. The cost is in applying them, and the scope of application will determine the amount. Initial costs are estimated at 36 staff-months for the first year and 12 staff-months per year for the remaining 4 years in the FYDP. In addition, the R&D cited in the literature suggest that cost savings and avoidances realized by using these strategies will significantly exceed the costs to implement them.

I. RAPID CONVERSION OF LESSONS LEARNED

1. Concept and Rationale

For today's rapidly evolving operational environments, lessons learned in theater are of critical importance in training. Technology can and should be exploited to improve the adaptability and agility of individuals, teams, and units. Capabilities that bring us increasingly closer to this goal are being developed. Among these capabilities are those developed by the Representing Enriched CONtext (RECON) project. Such projects enable personnel in theater to enter their experiences, or "war stories," quickly and easily into databases that can be "understood" and searched on a computer. Once these experiences have been entered, the computers, using techniques developed by machine learning research efforts, can abstract principles from them for ready application to training, performance aiding, and decision aiding.

TRADOC should begin a systematic effort to apply these capabilities in training as a way to maximize institutional learning adaptability and improve linkages between the generating force and the operating force.

2. Estimated Costs

The proposed project will examine the various channels through which lessons learned are gathered and processed and the types of information obtained from them. This information will be used to develop data-packaging methods (e.g., meta tags) that

are compatible with these various channels and provide information on which training developers can act.

The Y1 start-up costs (24 staff-months) cover the effort to develop these methods, whereas the follow-on funding (12 staff-months per year for the remaining 4 years in the FYDP) is for implementing the methods in an operational environment.

III. DEVELOP LEADERS

For several years, the U.S. Army has recognized the need to develop self-aware, adaptive leaders who can perform effectively in a broad range of situations across the full spectrum of operations. This working group examined what we know about adaptability and explored possible strategies for accelerating the growth of key leader skills that are thought to support adaptability. The group also discussed some of the organizational factors (socialization, cohesion) that help to establish the climate within which adaptable leaders perform.

A. LEADER SOCIALIZATION

1. Concept and Rationale

A recent study about the development of Army leaders says that leaders should “...create a command climate that supports operational excellence and also motivates competent people to continue their military service” (Ulmer, Shaler, Bullis, DiClemente, and Jacobs, 2004). To create that climate, this study highlights two leader behaviors involving socialization skills of major significance:

1. Gets out of the headquarters and visits the troops
2. Builds and supports teamwork within staff and among units.

Officers who participated and responded included the Commanders, Assistant Division Commanders, Chiefs of Staff, 8 members of each Division Staff, and from 6 to 10 subordinate commanders in each Division. They rated the socialization items above as “most important for setting climate” and “behaviors for Division Commanders to work on.” The question here is how such socialization skills can be enhanced in officer career development.

Leader socialization with troops is different from Soldier socialization in peer groups. Peer groups have day-to-day activities and participation in classes and in units for getting acquainted and developing cohesion. In contrast, leaders need to make themselves available to their troops to foster respectful socialization, and that challenge is increasingly difficult because of the emphasis on distributed operations, electronic networks, and larger (remote) areas of responsibility. One way to proceed is to take

advantage of electronic communication as a means of helping instead of hindering the socialization process.

Research with peer groups (Blanch, Orvis, and Wisher, 2003) shows that Web-based communication before face-to-face meetings can accelerate the socialization process. The technique was demonstrated in a trial application for reserve component officers enrolled in the Armor OAC. It worked by using text messaging during a block of instruction before resident coursework. A similar technique should be explored to determine the benefits provided to Commanders who routinely exchange information with their Soldiers. These should be day-to-day communications and not only “special messages from your Commander.” Topics (e.g., updates on daily activities and staff meetings) should encourage similar information exchanges from the Soldiers. These exchanges would provide a foundation for more meaningful face-to-face visits. Collaborative technologies (e.g., text messaging) for influencing socialization warrant further investigation, particularly in combination with the ARFORGEN model that includes a form of force stabilization. Force stabilization emphasizes Leader socialization with the Soldiers as an important way ensure a good long-term working relationship.

2. Estimated Costs

The cost of this study is estimated at about 18 staff-months plus costs of implementation per course or application, estimated at 8 staff-months. For costing purposes, a single test course is assumed to be developed for testing purposes. The study involves two phases: (1) assess the benefits of collaborative technologies for classroom or Commander-unit socialization and (2) verify its utility through interviews with officers who had the socialization experience and those who did not. Implementation would incur the cost of configuring networks for day-to-day within-group communications, designing computer-based introductions to new assignments or courses, and combining these with collaborative technologies.

Costs pertain to coordinators required to configure a specific socialization capability and to educate users. This cost would be applicable for each implementation. If successful, the Army could, with little to no added expense, introduce the approach broadly using available computer equipment.

B. CRITICAL THINKING SKILLS

1. Concept and Rationale

Ample evidence exists that critical thinking skills (CTS) have value for battle command and tactical decision making, particularly when uncertainty and time pressure are factors. At the same time, according to an Army workshop report, *Training Critical Thinking Skills for Battle Command* (Reidel, Morath, and McGonigle, 2001), little consensus exists on what exactly constitutes critical thinking and how it should be measured. This proposal suggests that the Army intensify its efforts to implement training of critical thinking based on experience gained previously.

In general, we can characterize critical thinking as an ability to assess one's own thinking and the thinking of others to gain understanding and achieve wise(r) judgments. Ample descriptions about critical thinking's concepts, values, and principles to help inform our learning strategies supplement this broad definition. More difficult, however, is the development of good methods and procedures for learning and performing critical thinking.

A plausible strategy for developing CTS combines information-based instruction on the concepts (knowledge), demonstration of the processes (performance-based), and guided practice (coaching/feedback) with realistic problems. Yet, the primary implementation information (e.g., Cannon-Bowers and Salas, 1998; Gerras, 2006; and Reidel et al., 2001) is mostly concerned with theories and general procedures for how to develop critical thinking. Far fewer specifics are available about what to do and what works.

An Army example of good instructional principles is the Think Like A Commander (TLAC) vignette program to train adaptive leaders from the Brigade Commander down. It presents a simulation of a situation to a commander in the context of a general problem that he has experienced previously but with a different specific-problem situation. The commander works through his interpretation, his reasoning, and the types of possible actions. Information is provided to relate that thinking back to the problem-solving thinking processes of great commanders. Through a series of vignettes, a commander starts to think more about the process of resolving problems while he practices critical thinking.

Using the same kind of teaching strategy represented by TLAC, the Army has begun adding more capability to foster critical thinking. An initial implementation has begun at the U.S. Military Academy, West Point. In addition, several Army schools—

Army Management Staff College (AMSC), Command and General Staff College (CGSC), Army War College (AWC)—have explored various curricula for critical thinking. The Center for Army Leadership (CAL) has a current effort developing measures. A recent effort just completed by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) uses Web-based training to focus on eight CTS. Each skill module is 2 hours long although longer versions (8 to 10 hours) for four of the skills are available. This product is ready to deliver now.

Teaching critical thinking is expanding in the Army. However, four recommendations (about what to teach) presented originally in the Workshop about training critical thinking (Reidel et al., 2001) need added attention:

1. **Train interpersonal skills for the application of critical thinking.** One of the barriers to the use of critical thinking is social awkwardness. Learning about critical thinking is important, but its use will be limited unless others accept it and one's command supports it.
2. **Model the use of critical thinking skills.** Training should immerse students in the critical thinking process, either through working with someone who is critically thinking or by showing them how to work through the problem using a set of principles. Thus, facilitators must be good critical thinkers and receive training and feedback in critical thinking.
3. **Train for transfer of training.** Even using simulations, all possible situations cannot be simulated. Methods for facilitating transfer of training to other situations are available and should be used when developing critical thinking training programs.
4. **Include critical thinking training in every course taught in the Army.** This can be accomplished easily on one level by emphasizing elements (e.g., asking open-ended questions and reinforcing the concept of working through problems) that promote critical thinking. Far more difficult is training someone to deal with novel situations through the use CTS and interactive exercises as part of the course design.

Overall, the Army seems to be acquiring good experience in teaching critical thinking and should increase efforts to offer more courses. For maximum effect, the Army should blend its past experience with these four recommendations to improve the teaching and the use of critical thinking.

2. Estimated Costs

To teach critical thinking systematically, the cost of this project would be on the order of 24 staff-months for each new course preparation. Augmenting a course with

critical thinking exercises should be possible for one-quarter to one-half that amount. The costing projections assume that a minimum of two new courses will be developed and that two courses will be augmented. Maintaining each course would require about 1 staff-month per year thereafter. The benefit would be improved efficiency and effectiveness not just for training of CTS, but also for solving problems on the asymmetric battlefield and in stability operations.

C. EXPERIENCE-BASED LEARNING METHODS

1. Concept and Rationale

The study of past conflicts and their successes and problems is an integral part of learning leader skills. Leaders read and discuss accounts of battle strategies and tactics, illustrating points with the help of situation maps, AARs, photos, and video. Personal accounts from veterans sometimes add color and detail. A newer development is the use of multimedia technology to enhance the experience, illustrated with examples from the Mazar-e Sharif campaign in Afghanistan in 2001 (Knarr and Richbourg, 2007).

The concept is to develop digital versatile discs (DVDs) with data, analyses, and lessons learned. However, the DVD's built-in capability allows much more than that. The DVD is set up to be conducive to discovery or directed learning at multiple levels and from different perspectives and analytical approaches. For Mazar-e Sharif, the material is said to be robust enough to support nine topics, as follows:

1. Traditional (as threads develop during research)
2. Levels of war (tactical, operational, strategic)
3. Principles of war (Mass, Objective, Offense, Surprise, Economy of Force, Maneuver, Unity of Command, Simplicity)
4. Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities (DOTMLPF)
5. Diplomatic, Information, Military, Economic (DIME)
6. Mission, Enemy, Terrain and weather, Troops – Time, Civil (METT-TC) considerations to include cultural aspects
7. Hypothesis testing
8. Case study
9. Staff rides.

For example, the second topic—levels of war—can be used to analyze various campaign aspects: political, cultural, alliances, information operations, interdependencies, rules of engagement (ROE), logistics, and adaptability. The approach allows drilling into and developing a subtopic such as ROE, which specify the circumstances and limitations under which forces conduct operations other than war (OOTW) or begin or continue combat. The index for the Mazar-e Sharif example points to several video clips, audio clips, and transcripts that specifically address or relate to ROE. One discussion is about the problems associated with positively identifying targets from aircraft at 20,000 feet. The lead-in to that is “Boots on the Ground,” where the Secretary of Defense explains the need for ground troops: “In Afghanistan, precision-guided bombs from the sky did not achieve their effectiveness until we had boots and eyes on the ground to tell the bombers exactly where to aim.” Another discussion by General Franks is about “How well ROE supported the targeting process” and “How he would consider changing the ROE development process to support the mission.” Such information, combined with battle re-creations using computer-generated virtual worlds, provides a powerful educational tool for senior-level conferences and leader development courses.

The DVD capability to learn from experience is a technology-rich way to develop leader skills based on past conflicts. Multimedia battle re-creations, expert commentaries, and supporting materials allow leaders to study and analyze near-real combat conditions from command, Soldier, and enemy perspectives. It is the next best thing to being there. The Army should take advantage of not only the materials on Mazar-e-Sharif, which is ready for use, but should also develop further two other such re-creations: the Battle of 73 Easting from the 1991 Gulf War and the Battle for Fallujah, Iraq, in 2004.

2. Estimated Costs

This implementation is possible for the cost—estimated at 24 staff-months—of developing teaching points emphasizing specific themes (e.g., cultural sensitivity; adaptability) to accompany a multimedia battle re-creation and about 3 to 6 staff-months to IOC. Maintenance costs would be about 1 staff-month per year thereafter. Teaching development should focus on the needs of particular schools and be done in cooperation with their subject matter experts (SMEs).

IV. FUTURE CAPABILITIES

Members in this working group envisioned what learning science and emerging technologies will offer within the next decade and articulated how the Army might train Soldiers and develop leaders more effectively.

A. IMPROVISATION

1. Concept and Rationale

During the conference, much discussion centered on developing “adaptive” leaders, without much being offered to specify what that means. At the same time, one participant (Wayne Hodgins) brought up the (undeveloped) notion of “strategic forgetting.” What, he wondered, might it mean if unlearning past norms of behavior became useful in the *future*? This question rekindled the story of an accomplished pianist who was having a terrible time learning a new, radical piece of music because it required that she get off the piano stool, stand up, walk around to the side of the piano and strike the strings directly with her fists. Maybe unlearning “norms” is worth investigating.

Most of the literature on improvisation seems to focus on musical or theatrical performance, both of which require massive content domain knowledge before the practice of improvisation can begin. This did not seem helpful, as we are advised that adaptability skills in the Army have to be pushed down the ranks to less-experienced personnel. Researching “instruction to develop adaptive leaders” yields lots of information in Master of Business Administration (MBA) programs and in educational (i.e., school) leadership programs, but, again, these appear to be focused on extending traditionally fixed bounds of knowledge along historically established domains.

Perhaps more interesting is research done at the edges of experience, such as that conducted with individuals who have autism (Marckel, Neef, and Ferreri, 2006):

Language and communication are major areas of concern for children with autism (*Diagnostic and Statistical Manual of Mental Disorders*, American Psychiatric Association, 2000). Research has shown that augmentative and alternative communication (AAC) systems, such as sign language, electronic communication aids, and the picture exchange communication system (PECS), can increase the communicative interactions of children with

autism and enable them to exercise control over their environments (e.g., by making requests)...

Fields at less-certain, farther edges of practice such as this [e.g., stranded mountain climbers, emergency room physicians, and National Aeronautics and Space Administration (NASA) astronauts] may offer more promising leads. The Wharton School at the University of Pennsylvania has conducted some research in this area, defining a concept of “resiliency” as being particularly pertinent.

Directly teaching the art of “improvisation” might be one way of addressing the needed “adaptive” capabilities in a purposeful manner, rather than in an indirect manner.

2. Estimated Costs

Several cohorts would have to participate in a candidate training program that included individual aptitude, capability, and personality tests. The estimated level of effort for this work would be about 9 staff-months. Follow-on field studies would also be needed. A curriculum might be developed for as little as 12 staff-months. Testing it would take a longer time, but no real benefit could be realized without such assessments. Testing time needed would be at least 36 staff-months. The benefits are hard to project, but this seems to be something everyone wants—without much science to support the oft-stated desires or to point to productive new directions.

B. FOLKSONOMIES

1. Concept and Rationale

Troops that benefit from the “lessons learned” of their predecessors are far more likely to survive than those who do not. Technologies that can support the capture, representation, and accessibility of “lessons learned” will be of great use to newly deployed Soldiers. Traditional knowledge-capture and knowledge-representation technologies have emphasized brittle technologies that can be exploited only by research scientists. These technologies are of no use to individuals who do not have highly specialized educations (i.e., enlisted personnel). New forms of knowledge-capture technologies offer greater promise in the form of “folksonomies.” Reporting in *Wired.com*, Terdiman (2005) described these technologies as follows:

These days, a growing number of sites whose content is user-created rely on tagging systems, also known as folksonomies, for the added value Butterfield is talking about. Flickr and the social-bookmarking site

Delicious, along with Furl, are generally considered folksonomy trailblazers, but now sites like MetaFilter and the blog index Technorati have jumped on board, and more are expected to follow.

“It’s very much people tagging information so that they can come back to it themselves or so that others with the same vocabulary can find it,” said Thomas Vander Wal, the information architect credited with coining the term ‘folksonomy.’

“To me, they’re a great new organization tool for applications and large content sites,” said Matt Haughey, the founder of MetaFilter. “Tags are great because you throw caution to the wind, forget about whittling down everything into a distinct set of categories and instead let folks loose categorizing their own stuff on their own terms. It hasn’t always been easy to get users to take on such responsibility. But as more people understand what tags are, how they work, and why they’re important, the number of participants in folksonomies has grown.”

“Tags are great, but the thing that is hard is getting people to use them,” said Caterina Fake, who co-founded Flickr with husband Stewart Butterfield. “But the thing that has happened recently is they’ve become part of a social arena in which they are valuable not only to the individual but to the group.”

The Armed Services excel at developing identity communities. One could argue, however, that these are communities established by an assault on individuality and that this has negative consequences for future (creative) behavior. Much information is available to recommend the establishment of team vs. individual self-interest but as much information may be available to recommend the establishment of a sense of team created by professional capacities that are different from those officially recognized [i.e., in ways not accommodated by traditional military occupation specialties (MOSs) and other military distinctions] and in ways that might be not possible to predict.

Tools that would allow individuals and teams of deployed personnel to document and organize their experiences, replete with anomalies, personal reflection, speculation, and advisory commentary in their own language, would be valuable to newly deployed personnel trying to keep pace with ever-changing conditions on the ground. Newly deployed troops have little difficulty learning the “lingo” of the field, but they may have great difficulty learning the meaning and nuance of the language.

Ideally, data captured from the field would be fed back to residential training schools, where students would engage the content in high-fidelity training “games.” The high-end capacity of computer servers at the residential training schools would provide

for realistic scenarios, imparting a high degree of engagement through the luddologic aspect of game-play behavior and the consequent, narratologic sense of self-agency that is realized in virtual environments with highly probable consequences.³ This game environment would teach the skills required by on-line community development, based on situational needs. Fielded, hand-held tools could maintain the task development activities of data capture and taxonomy development for real-time use and would recall benefits of the narratologic aspect of the residential game-play environment.

2. Estimated Costs

An anthropological study of practices in use in the field (to be institutionalized in technology) could be accomplished for 36 staff-months. Game development costs could range from \$3M to \$9M. Development of software for commercial off-the-shelf (COTS) hand-held devices for knowledge capture and representation could cost \$1M to \$2M.

C. TEAM TASK ANALYSIS/BEHAVIOR MODELING

1. Concept and Rationale

Much has been done for team or group task analysis. The Department of Defense (DoD) has paid for most of it. ARI has conducted much research in this area, but most of what has resulted appears to be brittle and of little help in being predictive.

Research that looks to be effective in modeling crowd behavior under various circumstances is ongoing. The reverse of the statistical Simpson effect⁴ may be at work.

³ Luddologic and narratologic: Narratology is the study of narrative and narrative structure and the ways they affect our perception. The narrativists' approach video games in the context of what Janet Murray (Professor at Georgia Tech) calls "Cyberdrama." The narrativists' major concern is with video games as a storytelling medium, one that arises out of interactive fiction. The ludologists break sharply from this view. Their perspective is that a video game is first and foremost a game and that it needs to be understood in terms of its rules, interface, and in terms of the concept of play. The term ludology arose within the context of non-electronic games and board games in particular but gained popularity after it was featured in a 1999 article by Gonzalo Frasca (a game designer and academic researcher). The name, however, has not yet caught on fully. Major issues in the field concern questions of narrative and of simulation and whether video games are either, neither, or both.

⁴ Simpson's paradox (or the Yule-Simpson effect) is a statistical paradox wherein the successes of groups seem reversed when the groups are combined. This result is often encountered in social and medical science statistics and occurs when a weighting variable, which is irrelevant to the individual group assessment, must be used in the combined assessment.

This is an area in which many people are interested but little is being accomplished. Again, closed-ended computational models, the workings of which no one can explain (e.g., Latent Semantic Analysis), may not have anything to do with reality.

Why not start with an anthropological model based on field studies of what people actually do, how they describe effectiveness, and so forth?

2. Estimated Costs

A \$1-M effort to study the differences between the use of anthropological vs. computer-science models would be fascinating.

APPENDIX A

REFERENCES

- Atkinson, R. C., and Wilson, H. A. (1969). *Computer-assisted instruction: A book of readings*. New York: Academic Press.
- Battle Command Knowledge System. (2007, August 27). In *Wikipedia, The Free Encyclopedia*. Retrieved September 7, 2007, from http://en.wikipedia.org/w/index.php?title=Battle_Command_Knowledge_System&oldid=154054983
- Blanch, J., Orvis, K. L., and Wisher, R. A. (2003). *Web-based collaborative learning: Communication between learners within a virtual tactical operations center*. (Research Report 1808). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe and A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 185–205). Cambridge, MA: MIT Press.
- Bjork, R. A. (2007). How we learn versus how we think we learn: implications for the optimization of army training [Briefing in Appendix CD of *The Army science of learning workshop* (ARI Research Note 2007-2)]. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Brooks, P. S., Hofmann, M. A., Johnson, E. M., LeMoyné, J. M., Morrison, J. E., Suttén, C. G., and Wright, R. K. (2005, September). *Evaluation of the Battle Command Knowledge System (BCKS): Interim report* (IDA Paper P-4061). Alexandria, VA: Institute for Defense Analyses.
- Bruner, J. (2004). *Toward a theory of instruction*. Cambridge, MA: Belknap Press.
- Cannon-Bowers, J. A., and Salas, E. (Eds.). (1998). *Decision making under stress: Implications for training and simulation*. Washington, DC: American Psychological Association.
- Dodds, P. V. W., and Fletcher, J. D. (2004). Opportunities for new “smart” learning environments enabled by next generation web capabilities. *Journal of Education Multimedia and Hypermedia*, 13(4), 391–404.
- Fletcher, J. D. (2002). Is it worth it? Some comments on research and technology in assessment and instruction. In *Technology and assessment: Thinking ahead* (pp. 26–39). Washington, DC: National Academy of Science.

- Fletcher, J. D., and Rockway, M. R. (1986). Computer-based training in the military. In J. A. Ellis (Ed.), *Military contributions to instructional technology* (pp. 171–222). New York: Praeger Publishers.
- Fletcher, J. D. (1975). Models of the learner in computer-assisted instruction. *Journal of Computer-Based Instruction*, 3, 118–126.
- Fletcher, J. D. (1992). Individualized systems of instruction. In M. C. Alkin (Ed.), *Encyclopedia of educational research (6th edition)* (pp. 613–620). New York, NY: Macmillan.
- Fletcher, J. D. (1997). What have we learned about computer based instruction in military training? In R. J. Seidel and P. R. Chatelier (Eds.), *Virtual reality, training's future?* (pp. 169–177). New York, NY: Plenum Publishing.
- Fletcher, J. D. (2006). A polymath in every pocket. *Educational Technology*, 46, 7–18.
- Foster, R. E., and Fletcher, J. D. (2003). *Modeling the user for education, training, and performance aiding* (IDA Document D-2920). Alexandria, VA: Institute for Defense Analyses.
- Galanter, E. (Ed.). (1959). *Automatic teaching: The state of the art*. New York: John Wiley & Sons.
- Gerras, S. J. (2006). *Thinking critically about critical thinking: A fundamental guide for strategic leaders*. Carlisle Barracks, PA: U.S. Army War College.
- Keller, F. S. (1968). Goodbye, teacher *Journal of Applied Behavior Analysis*, 1, 79–89.
- Keller, F. S. (1985). Lightning strikes twice. *Teaching of Psychology*, 12, 4–8.
- Knarr, W. M., and Richbourg, R. F. (2007). *Learning from the first victory of the 21st century: Mazar-e Sharif* (IDA Draft Document). Alexandria, VA: Institute for Defense Analyses.
- Marckel, J. M., Neef, N. A., and Ferreri, S. J. (2006). A preliminary analysis of teaching improvisation with the Picture Exchange Communication System to children with autism. *Journal of Applied Behavior Analysis*, 39, 109–115.
- Orlansky, J., and String, J. (1979). *Cost-effectiveness of computer based instruction in military training* (IDA Paper P-1375). Alexandria, VA: Institute for Defense Analyses.
- Orlansky, J., and String, J. (1981). *Cost-effectiveness of maintenance simulators for military training* (IDA Paper P-1568). Alexandria, VA: Institute for Defense Analyses.

- Reidel, S., Morath, R. A., and McGonigle, T. P. (2001). *Training critical thinking skills for battle command* (ARI Workshop Proceedings, 5–6 December 2000, Fort Leavenworth, KS). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Scriven, M. (1975). Problems and prospects for individualization. In H. Talmage (Ed.), *Systems of individualized education* (pp. 199–210). Berkeley, CA: McCutchan Publishing Corp.
- Suppes, P., and Morningstar, M. (1972). *Computer-assisted instruction at Stanford 1966–68: Data, models, and evaluation of the arithmetic programs*. New York: Academic Press.
- Terdiman, D. (2005, February 1). Folksonomies tap people power. *Wired.com*. Retrieved March 14, 2007 from <http://www.wired.com/news/technology/0,1282,66456,00.html>
- Ulmer, W. F., Shaler, M. D., Bullis, R. C., DiClemente, D. F., and Jacobs, T. O. (5 November 2004). *Leadership lessons at division command level – 2004*. Carlisle, PA: U.S. Army War College.
- Wisher, R. A. and Fletcher, J. D. (2004). The case for advanced distributed learning. *Information & Security: An International Journal*, 14, 17–25.

APPENDIX A

GLOSSARY

AAC	augmentative and alternative communication
AAR	after action review
AMSC	Army Management Staff College
AoA	analysis of alternatives
AOT	assignment-oriented training
ARFORGEN	Army Force Generation
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
AWC	Army War College
BCKS	Battle Command Knowledge System
CAL	Center for Army Leadership
CEU	Continuing Education Unit
CGSC	Command and General Staff College
COTS	commercial off-the-shelf
DIME	Diplomatic, Information, Military, Economic
DoD	Department of Defense
DOTMLPF	Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities
DVD	digital versatile disc
GEL	Guided Experiential Learning
HPI	Human Performance Improvement
IET	Initial Entry Training
IOC	initial operating capability
ISD	Instructional Systems Design
ITS	Intelligent Tutoring System
KM	knowledge management
LMS	Learning Management Systems
MBA	Master of Business Administration
MEC	Mission Essential Capability
METT-TC	Mission, Enemy, Terrain and weather, Troops – Time, Civil
MOS	military occupation specialty
NASA	National Aeronautics and Space Administration

OAC	Officer Advanced Course
OOTW	operations other than war
PECS	picture exchange communication system
PoA	plan of action
POI	program of instruction
R&D	research and development
RECON	Representing Enriched CONtext
ROE	rules of engagement
ROI	return on investment
SAT	System Approach to Training
SME	subject matter expert
TLAC	Think Like A Commander
TRADOC	U.S. Army Training and Doctrine Command

APPENDIX B.
CUMULATIVE COSTS AND BENEFITS TABLES

Table B-1. Cumulative Y1 Costs and Benefits

Short Titles	Cumulative Y1 Costs (K Dollars)	Cumulative Proportion of Total Benefit
New Training R&D	23,417	1.000
Folksonomies	14,042	0.988
HPI in the Army	11,792	0.978
Training Support Tools	11,292	0.971
Improvisation	10,292	0.947
Critical Thinking Skills	9,854	0.934
Leader Socialization	8,604	0.891
Predictive Models	8,063	0.870
Life-long Learning	7,313	0.835
Team Task Analysis	6,313	0.783
The GEL Model	5,313	0.726
R&D on dL	5,063	0.708
Knowledge Management	4,563	0.667
Experience-Based Learning	3,563	0.585
Blended Learning	3,063	0.537
Training Capabilities	2,875	0.518
Diagnostic Evaluation	2,500	0.474
Lessons Learned	1,750	0.380
Implementation Plan for dL	1,250	0.314
Analyses of Training	542	0.180
Tailored Training	250	0.114

Table B-2. Cumulative FYDP Costs and Benefits

Short Titles	Cumulative FYDP Costs (K Dollars)	Cumulative Proportion of Total Benefit
New Training R&D	76,417	1.000
Folksonomies	29,542	0.988
Improvisation	21,292	0.978
HPI in the Army	20,104	0.965
Training Support Tools	19,604	0.958
R&D on dL	18,104	0.934
The GEL Model	15,604	0.893
Life-long Learning	14,854	0.875
Critical Thinking Skills	12,854	0.823
Leader Socialization	11,271	0.780
Knowledge Management	10,729	0.760
Lessons Learned	8,729	0.677
Predictive Models	7,229	0.611
Diagnostic Evaluation	6,479	0.575
Team Task Analysis	4,729	0.481
Analyses of Training	3,729	0.425
Training Capabilities	2,771	0.358
Experience-Based Learning	2,146	0.314
Blended Learning	1,563	0.266
Implementation Plan for dL	1,375	0.248
Tailored Training	500	0.114

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